Citation:
Blakemore, R.J. (2008b). Review of Oriental pheretimoids (*Pheretima* auct. family Megascolecidae) with description of a new genus [*Duplodicodrilus* gen. nov.]. In: T. Pavlicek & P. Cardet (eds.). Advances in Earthworm Taxonomy III. Ministry of Agriculture, Natural Resources and Environment of the Republic of Cyprus, Nicosia. Pp. 23-36.

Review of Oriental pheretimoids (*Pheretima* auct. Megascolecidae) with description of a new genus

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Checklists of all known members of the *Pheretima*-group now include 13 genera and ca. 920 (sub)species from a total of >1,300 taxa, including numerous synonyms, invalid names and *lapsae*. Several replacement names of homonyms were required as provided for under ICZN (1999 Art. 57). Other new combinations and new synonyms were flagged whereas numerous *species inquirendae* / *incertae sedis* and *nomina nuda* remain unresolved. Full taxonomic resolution probably requires DNA 'fingerprinting', preferably of (neo)types, especially for the numerous parthenogenetically deteriorated polymorphs. Male pore characteristics define genera and there is progression from superficial male pores in the prior 'default' genus *Amynthas* Kinberg, 1867: 97 to non-superficial in *Pheretima* Kinberg, 1867: 102 and *Metaphire* Sims & Easton, 1972. Species similar to *Metaphire schmardae* (Horst, 1883) having large, eversible and duplicated pairs of male intromittant organs or pseudo-penes (and manicate intestinal caeca) merit placement in a new genus, *Duplodicodrilus* **gen. nov.**. This newly proposed genus is the most derived in its complex male organs – used for mutual charging of spermathecae – differing to those in the type of *Metaphire* and further lacking the spermathecal nephridia typical of *Pheretima s. stricto*.

INTRODUCTION

'Housekeeping' revisions by Blakemore (2003a,b; 2004; 2005; 2006a,b) progressively checklisted ca. 920 (sub)species from a total of >1,300 taxa, including numerous synonyms of all known pheretimoids (i.e. *Pheretima* auct. *sensu lato*). Replacement names for several homonyms were required as provided for under ICZN (1999 Art. 57) and these are listed under Results below. The permanently invalid primary homonym *Pheretima montana* Ishizuka, 1999 of *Ph. montana* Kinberg, 1867, the type species of the genus, was not replaced as, under ICZN (1999: Art. 60), its valid synonym is considered to exist in Japan as *Amynthas fuscatus* (Goto & Hatai, 1898), see Blakemore (2003a; 2006). Other new combinations and new synonyms are noted in Blakemore (2006) whereas numerous *species inquirendae* / *incertae sedis* and *nomina nuda* remain unresolved. The *Pheretima*-group, currently of 13 genera, had previously consisted of about 800 nominal taxa from Sims & Easton (1972) and Easton (1979) for which Sims (1983) thought about half (ca. 400) were valid species. Diagnoses of the genera and importance of male organs are discussed in Blakemore (2002; 2003a; 2006; 2007). Species similar to *Metaphire schmardae* (Horst, 1883) having large, eversible and duplicated pairs of male intromittant organs or pseudo-penes (and manicate intestinal caeca) merit placement in a new genus as described herein.

MATERIALS AND METHODS

Revisions of taxa comply with ICZN (1999) that requires replacement of permanently invalid primary homonyms. Characteristics of all 12 prior pheretimoid genera, based primarily on the condition of the male pores, are tabulated (Table 1) and are compared with those of the newly proposed genus. The male pores of representative species (similar to types) are figured and compared.

TAXONOMIC RESULTS

Replacement names, provided under ICZN (1999 Art. 57) for primary homonyms were: anagrammatic *Pheretima asurgo* Blakemore, 2006b for *Ph. rugosa* James, 2004 (non *Ph. houlleti rugosa* Gates, 1926); patronymic *Amynthas gegatesi* Blakemore, 2006a for *Ph. dolosa* Gates, 1932: 443 (non *Ph. doliaria dolosa* Gates, 1932: 416); *Amynthas papilio vespertilio* Blakemore, 2006a for *Ph. papilio insignis* Gates, 1932 (non *Ph. insignis* Michaelsen, 1921); *Ph.* (*Parapheretima*) *barbara barbigua* Blakemore, 2004: 129 for *Ph.* (*Parapheretima*) *barbara ambigua* Cognetti, 1913: 302 (non *Ph. ambigua* Cognetti, 1906); and *Pheretima*? *palarva* Blakemore, 2003a for *Ph. parvula Ishizuka* et al., 2000 [non *Ph. parvula* Ohfuchi, 1956 (= *Metaphire parvula*) nec *Perichaeta parvula* Goto & Hatai, 1889 (= *A. gracilis*)]. A secondary homonym replacement was *Amynthas andersoni doettrani* Blakemore, 2006a for *Ph. andersoni minima* Do & Tran, 1995 in Do, Tran & Le, 1995 [non *Perichaeta minima* Horst, 1893 (= *Amynthas minimus*)].

Genus *Duplodicodrilus* gen. nov.

Type-species *Megascolex schmardae* Horst, 1883: 194 from "Japan". [Non *Megascolex schmardae* Michaelsen, 1897: 208 from "foot of Adams Peak", Sri Lanka for which replacement is not automatically required and prevailing usage is maintained (under ICZN, 1999: Art. 23.9.5) since these taxa have not been considered congeneric after 1899, e.g. Michaelsen (1900) held them in separate genera]. Syntypes in Leiden: 1818 (inspected by Sims & Easton, 1972: 181) and sometimes (erroneously?) reported in Vienna: 3970 – not reinspected here.

Diagnosis Male pores within copulatory pouches on segment 18, eversible as large inflatable and doubled intromittant organs or pseudo-penes (Fig. 6). Genital markings lacking. Intestinal caeca

manicate or complex, paired in segment 27 (Fig. 7). Holandric. Spermathecal pores paired in 7/8/9.

Included species *Metaphire schmardae schmardae* (Horst, 1883) (type) [syns. ?*Perichaeta sumatrana*: Beddard, 1892a:155, Pl IX, fig. 4, (non *Megascolex sumatranus* Horst, 1883); *Perichaeta trityphla* Beddard, 1896: 205 from Barbados, types BMNH:1904.10.5.169; *Pheretima kikuchii* Hatai & Ohfuchi, 1936: 767 from Japan]; *M. schmardae macrochaeta* (Michaelsen, 1899: 235 is listed as a subspecies by Sims & Easton (1972: 239) which, as described by Michaelsen (1900: 302), is from Japan and "Tiensin, China" but it is not certain that its variations are outside of normal intraspecific variability and therefore this name may warrant merger with the nominal subspecies. Other possible candidate species are noted in Discussion below.

Etymology for the doubled, eversible copulatory organs resembling "air-bags" in this worm (gender masculine).

Distribution Oriental (Japan, China), the nominal type widespread by transportation.

Remarks Male organs of *Duplodicodrilus schmardae* differentiate it from other comparable pheretimoid genera: male pores are superficial in *Amynthas* Kinberg, 1867: 97 (Fig. 1) or non-superficial in *Pheretima* Kinberg, 1867: 102 (Fig. 2) and *Metaphire* Sims & Easton, 1972 (Figs. 3-5). The newly proposed genus is most derived in its complex eversible male organs (Fig. 6), combined with its complex intestinal caeca (Fig. 7) that is perhaps less taxonomically important. The elaborate eversible male organs of *Duplodicodrilus*, used for mutual charging of spermathecae, differ from those found in *Metaphire* and, moreover, lack of spermathecal nephridia differentiate both from *Pheretima s. stricto*.

[FIGS 1-6 hereabouts]

DISCUSSION

Reproductive male organs are seen as one of the most important taxonomic characters whereas the condition of the digestive intestinal organs (e.g. presence or absence of caeca), although used in pheretimoid taxonomy, are subordinate (Michaelsen, 1900; Sims & Easton, 1972; Easton, 1979; cf. James, 2004). Concerning male pores of *Amynthas/Metaphire/Pheretima*/*Duplodicodrilus*, their determination is straightforward when we have clear differences such as in *Duplodicodrilus schmardae* (that has copulatory pouches resembling large "air-bags" when everted) but borderline cases may be difficult to decide (Fig. 5). In these cases the solution simply is to ask: "Are the male pores superficial?" (the plesiomorphic state found in *Amynthas*). If not, then they are 'non-superficial' (apomorphic as found in the other genera) and where they are large and eversible in specimens lacking nephridia on spermathecal ducts (also with manicate caeca), they now conform to *Duplodicodrilus*.

In further add to this reasoning, I quote Gates (1975: 7) on this question supporting separation of species with non-superficial male pores and with secondary division in the extent of their envelopment:

> "*Presence or absence of copulatory chambers is too vague. The really important character is whether the male pores are superficial or invaginate. In the latter case, whether in slight transverse slits of much deeper spaces still confined to the parietes or whether thick-walled copulatory chambers deeply penetrating into coelomic cavity (cf Gates, 1972: 150)*".

Complicating factors are that parthenogenetic morphs may lack male pores or, as stated by Easton (1982: 725), the techniques used to preserve specimens may cause copulatory pouches to evaginate making the male pores appear superficial (or vice versa), and, in immatures, the copulatory pouches may be undeveloped (Easton, 1979). Although DNA

analysis may help solve these problems, techniques to reveal the true form of the male pores are sectioning of fixed material or applying suction from a wide-mouthed syringe to freshly anaesthetized specimens however often mere placement into alcohol during preservation causes a natural eversion response.

Sims & Easton (1972: 181) inspected a syntype of *schmardae* (Leiden, L.1818) that separated out uniquely in their principal co-ordinates analysis (Sims & Easton, 1972: fig. 2) to a "*Metaphire schmardae* group". This group comprised synonyms plus *M. paeta* (Gates, 1935) from Szechuan that apparently differs in its deeply incised rather than manicate caeca (the exact state of its male pores is uncertain). Of their tested taxa, the nearest neighbour to *schmardae* was *Metaphire brinchangensis* (Stephenson, 1932) they placed in a "*Metaphire javanica* group" that includes the type species of the genus, *Metaphire javanica* Kinberg, 1876: 102, possibly a junior synonym of page-prior *Metaphire californica* Kinberg, 1876: 102 (see Figs. 3-4 and Blakemore, 2002).

Several other taxa are described with large and eversible male pores, possibly also forming doubled intromittent organs or pseudo-penes, that may qualify them for inclusion with *D. schmardae* in *Duplodicodrilus*. Likely candidates species are:

- *Metaphire bipora* (Beddard, 1900: 908) plus its synonyms from "Malay Peninsula" (including Singapore), Myanmar, and Thailand that has one or two pairs of genital markings (in 19 or 19 and 20) themselves resembling copulatory pouches, four pairs of spermathecae in 5/6/7/8/9 and simple intestinal caeca;
- and *M. virgo* (Beddard, 1900: 895) from Thailand, Malaysia and Myanmar with spermathecae in 6/7/8/9 that also has simple intestinal caeca.

Inclusion of these taxa would require expanding the generic definition to include their characteristics (e.g. simple caeca, extra spermathecal

pores and genital markings).

Less likely candidates also described with large eversible intromittent organs are:

- *M. kengtungensis* (Gates, 1931) from Myanmar and Laos with spermathecae in 7/8/9 that has glands within its copulatory pouches "*perhaps somewhat as in P. schmardae*";
- *M. quadrigemina* (Gates, 1932) from Myanmar with spermathecae in 6/7/8/9;
- *M. brevipenis* (Qiu & Wen, 1988) from Guizhou, China with spermathecal pores in 7/8/9 and simple caeca;
- and, questionably, *M. quelparta* (Kobayashi, 1937) from Cheju Island, South Korea with spermathecae in 6/7/8/9 plus its possible synonym *M. sanseiana* (Ohfuchi, 1951) from China.

Another possible member of this group would be Gates' (1972: 199) rather contradictory concept of *Metaphire malayana* (Beddard, 1900) [cf. *M. bipora* and *Pheretima (Pheretima) darnleiensis* as redescribed by Blakemore (2002; 2006; 2007)].

Determination of membership in *Duplodicodrilus* requires inspection of all the taxa listed above (plus their synonyms) probably including DNA 'fingerprinting', preferably of (neo)types, and their comparison with the type, but this work is beyond the resources of the current study and is deferred.

ACKNOWLEDGEMENTS

This study was supported in part by 21st Century COE "Environmental Risk Management for Bio/Ecosystems" at YNU. The proceedings organizer and editor, Dr Tomas Pavlicek, and proxy presenter Dr Csaba Csuzdi are thanked for their support and encouragement.

REFERENCES

Blakemore, R.J. (2002) *Cosmopolitan Earthworms – an Eco-Taxonomic*

Guide to the Peregrine Species of the World. VermEcology, PO BOX 414 Kippax, ACT 2615, Australia. Pp. 506 + including 80+ figs.

Blakemore, R.J. (2003a). Japanese Earthworms (Annelida: Oligochaeta): a Review and Checklist of Species. *Organisms, Diversity and Evolution*. 3(3): 241-244. [Published Sept., 2003 http://www.urbanfischer.de/journals/ode/].

Blakemore, R.J. (2003b). Japanese earthworms (Annelida: Oligochaeta): a review and checklist of species. *Organisms, Diversity & Evolution* 3(3): Electronic Supplement 2003-11. [Published Oct., 2003 http://www.senckenberg.de/odes/03-11.htm].

Blakemore, R.J. (2004). Checklist of Pheretimoid earthworms after Sims & Easton (1972). In: Moreno, A.G. and Borges, S. (eds.) *Avances en taxonomia de lombrices de tierra/Advances in earthworm taxonomy (Annelida: Oligochaeta)*. Editorial Complutense, Universidad Complutense, Madrid, Spain. Pp. 126-154. [Published July, 2004 in English with some Spanish translation].

Blakemore, R.J. (2005 Vol. 1; 2006a Vol. 2). Chapters in: *A Series of Searchable Texts on Earthworm Biodiversity, Ecology and Systematics from Various Regions of the World.* Eds. Ito, M.T. and Kaneko, N. CD-ROM publication by Soil Ecology Research Group, Graduate School of Environment & Information Sciences, Yokohama National University, 79-7 Tokiwadai, Yokohama 240-8501, Japan.

Blakemore, R.J. (2006b CD publication and 2007 online supplement). *A Series of Searchable Texts on Earthworm Biodiversity, Ecology and Systematics from Various Regions of the World – Series II Supplemental***.** Eds. Kaneko. N. and Ito M.T., COE Soil Ecology Research Group, Yokohama National University,

Japan. Publication online at YNU COE website http://bio-eco.eis.ynu.ac.jp/eng/database/earthworm/.

Blakemore, R.J., Ito, M.T., Kaneko N. and Kawaguchi, T. (2007 in press). Taxonomic status and ecology of Oriental *Pheretima darnleiensis* (Fletcher, 1886) and other earthworms (Oligochaeta : Megascolecidae) from Mt Kinabalu, Borneo. *Zootaxa* (submitted March, 2007 http://www.mapress.com/zootaxa/).

Easton, E.G. (1979). A revision of the 'acaecate' earthworms of the Pheretima group (Megascolecidae: Oligochaeta): *Archipheretima, Metapheretima, Planapheretima, Pleinogaster* and *Polypheretima*. *Bulletin of the British Museum (Natural History) Zoology*. **35(1):** 1-128.

Easton, E.G. (1982). Australian pheretimoid earthworms (Megascolecidae: Oligochaeta): a synopsis with the description of a new genus and five new species. *Australian Journal of Zoology*. **30:** 711-735.

Gates, G.E. (1972). Burmese Earthworms, an introduction to the systematics and biology of Megadrile oligochaetes with special reference to South-East Asia. *Transactions of the American Philosophical Society*. **62(7):** 1-326. [Online via subscription here http://links.jstor.org/journals/00659746.html].

Gates, G.E. (1975). On a few earthworms from New Guinea (Oligochaeta). *Megadrilogica* **2(1):** 6-8.

Hatai, S. and Ohfuchi, S. (1936). Description of one new species of the genus *Pheretima*. *Sci. Rep. Tohoku Imp.Univ.* **10(4):** 767-772.

Horst, R. (1883). New species of the genus *Megascolex* Templeton (*Perichaeta* Schmarda) in the collections of the Leyden Museum. *Notes Leyden Mus*. **5:** 182-196.

ICZN (1999). *International Code of Zoological Nomenclature* (4th

edition). International Trust for Zoological Nomenclature, c/o Natural History Museum, London. Pp. 306. [http://www.iczn.org/iczn/index.jsp].

James, S.W. (2004). New genera and species of pheretimoid earthworms (Clitellata: Megascolecidae) from southern Luzon, Philippines. *Systematics and Biodiversity*. **2(3)**: 271-279. [Sept., 2004, Published Online: 17 Jan 2005].

Michaelsen, W. (1900). *Das Tierreich* Vol. 10: Oligochaeta. Friedländer and Sohn, Berlin. Pp. XXIX+575.

Sims, R.W. (1983). The scientific names of earthworms. In: Satchell, J.E. (ed.). *Earthwom Ecology: from Darwin to Vermiculture*. Pp. 365-373. Chapman and Hall, London.

Sims, R.W. and Easton, E.G. (1972). A numerical revision of the earthworm genus *Pheretima* auct. (Megascolecidae:Oligochaeta) with the recognition of new genera and an appendix on the earthworms collected by the Royal Society North Borneo Expedition. *Biological Journal of the Linnean Society*. **4:** 169-268.

Table 1. Characters of *Pheretima*-group genera including *Dendropheretima* and *Isarogoscolex* from Philippines described by James, 2004 and *Duplodicodrilus* gen. nov.

Genus	Intestinal caeca (origin)	Male pore structure	Nephridia on spermathecal ducts	Other characters
Amynthas	25-28	Superficial	No or Yes	Holandric or metandric
Archipheretima	Absent	Superficial	No	Clitellum 13-16,17,18
Begemius	25	Superficial	No	Crescentic marks around male pores; metandric
Dendrophereti ma	25 simple pair	Superficial	No	Arboreal. Calciferous lamellae in 11-14; holandric. [Cf *Ephemitra* (= *Metapheretima*) or *Begemius*]
Duplodicodrilus	27 complex (always?)	Large double eversible, inflatable	No	Holandic. Genital markings typically absent
Isarogoscolex	From 29,30 two pairs	Superficial	No	Arboreal. Calciferous glands in 11-13. [Cf. *Pl. arboricola* (Rosa, 1890) from Myanmar]
Metapheretima	Absent	Superficial (no porophores) or pouched (with penes)	No	Crescentic markings usually around male pores
Metaphire	26-27	Pouched	No	Holandric, proandric or metandric
Pithemera	22-24	Superficial	No	
Pheretima (*Parapheretima*)	27	Pouched	Yes	Secretory diverticulum glands on copulatory pouches
Pheretima (*Pheretima*)	27	Pouched	Yes	No secretory diverticulum glands on copulatory pouches
Planapheretima	Absent or, 26-27	Superficial or pouched	No	Arboreal. Body flattened with “creeping sole”; crescentic marks present (type) or absent.
Pleionogaster	Absent	Superficial	No	Gizzards 26-28,29
*Polypheretima**	Absent	Superficial porophores or pouched (no penes)	No	No crescentic marks around male pores

*In *Polypheretima* the spermathecae may be multiple, i.e., polythecal as in some species of *Amynthas*, *Metapheretima*, and *Metaphire*, or aborted; when present, the diverticula are simple (cf. multilocular in *Archipheretima* and some *Metapheretima*). Cresentic marks around male pores (characteristic of *Begemius* and several species of other genera, e.g. *Metapheretima*, *Pleionogaster*, *Planapheretima*) not found in *Polypheretima*.

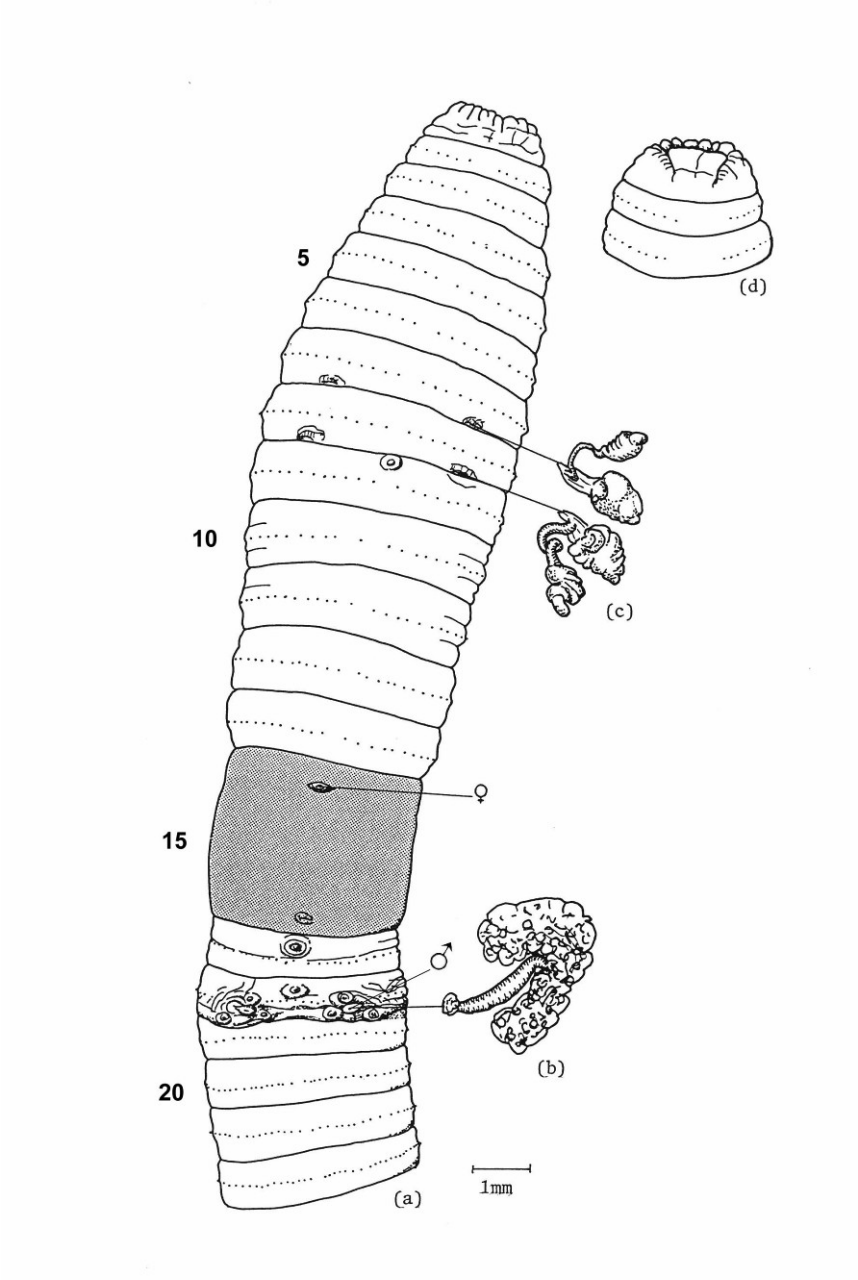

Fig. 1. Superficial male pores of *Amynthas aeruginosus rennellanus* (Gates, 1959) from Rennell, sub-species of *Amynthas* type *Amynthas aeruginosus* Kinberg, 1867; (a) ventral view (b) prostate (c) spermathecae *in situ* (d) prostomium (after Blakemore, 1997).

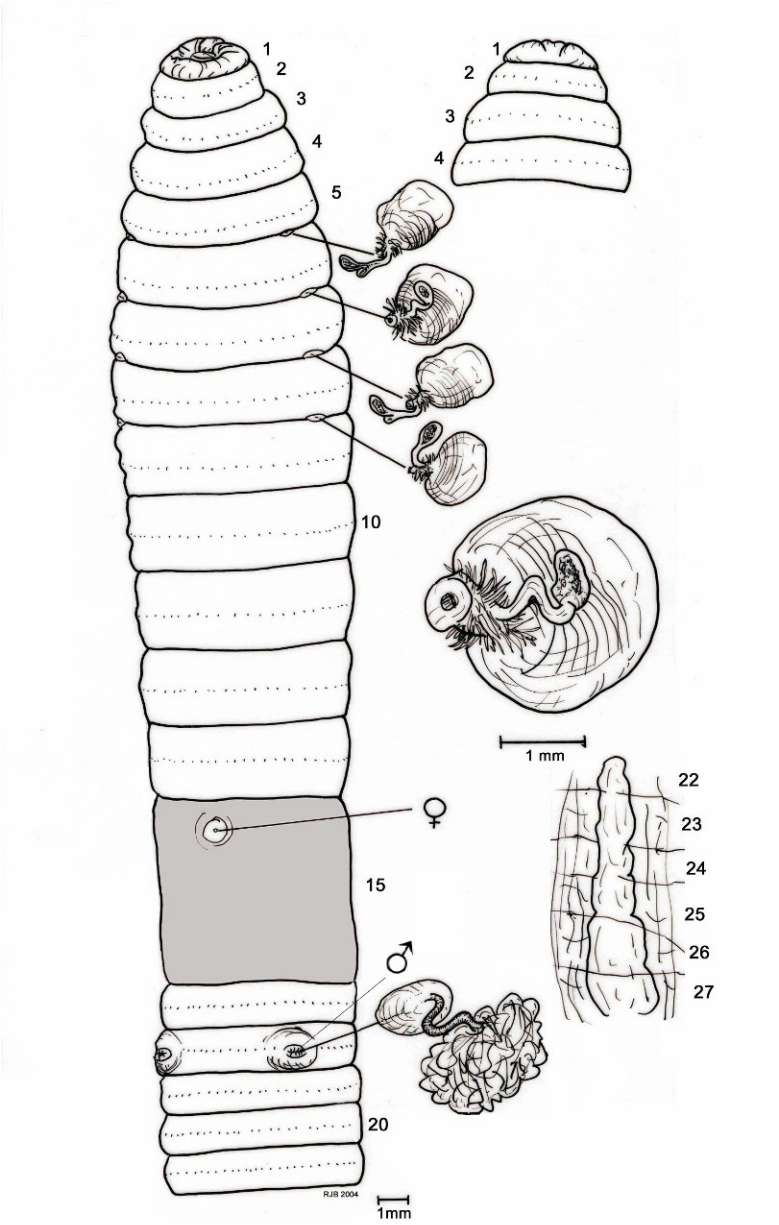

Fig. 2. Non-superficial male pores of *Pheretima (Pheretima) darnleiensis* (Fletcher, 1867) from Mt Kinabalu, Borneo. Figure shows prostomium, spermathecae and prostates in situ, with an enlargement of a spermatheca showing nephridia, plus intestinal caecum (after Blakemore *et al.*, 2007).

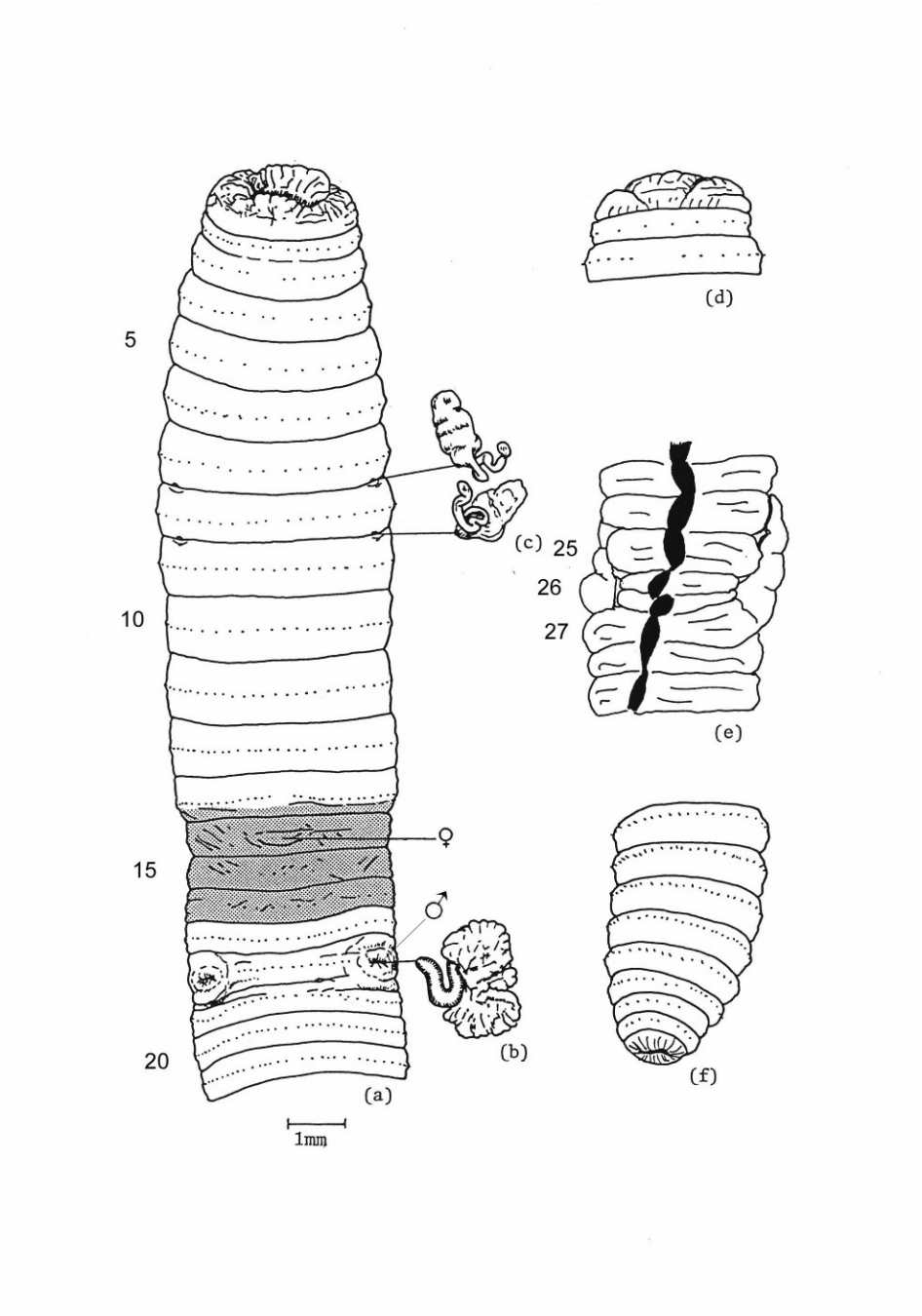

Fig. 3. Non-superficial male pores of *Metaphire californica* Kinberg, 1867: 102, specimen from Samford (Queensland). (a) ventral view, (b) prostate, (c) spermathecae, (d) prostomium, (e) intestinal caeca, (f) posterior (after Blakemore, 2002).

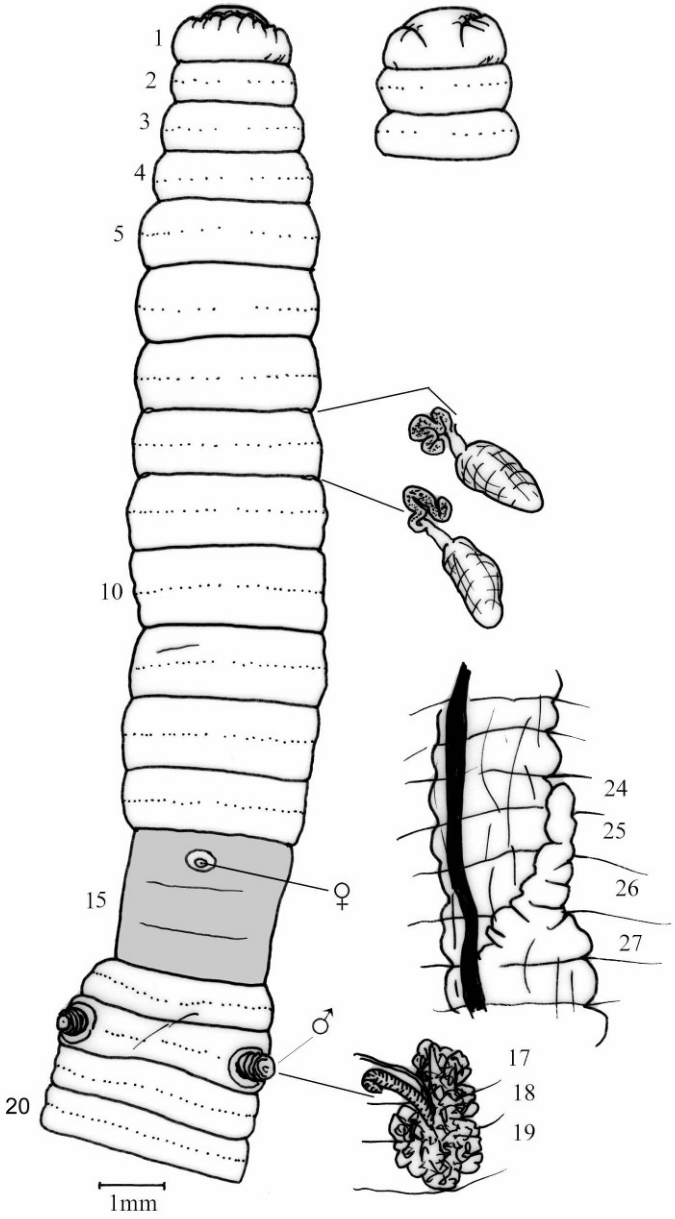

Fig. 4. Everted non-superficial male pores of *Metaphire californica*, specimen from Brisbane (Queensland) in Australian Museum as AM W.2682 (mis-)labeled as its probable synonym, the *Metaphire* type "*M. javanica* (Kinberg)" in January 1974 by E. G. Easton, the co-author of the genus (see Blakemore, 2002; cf. Fig. 3).

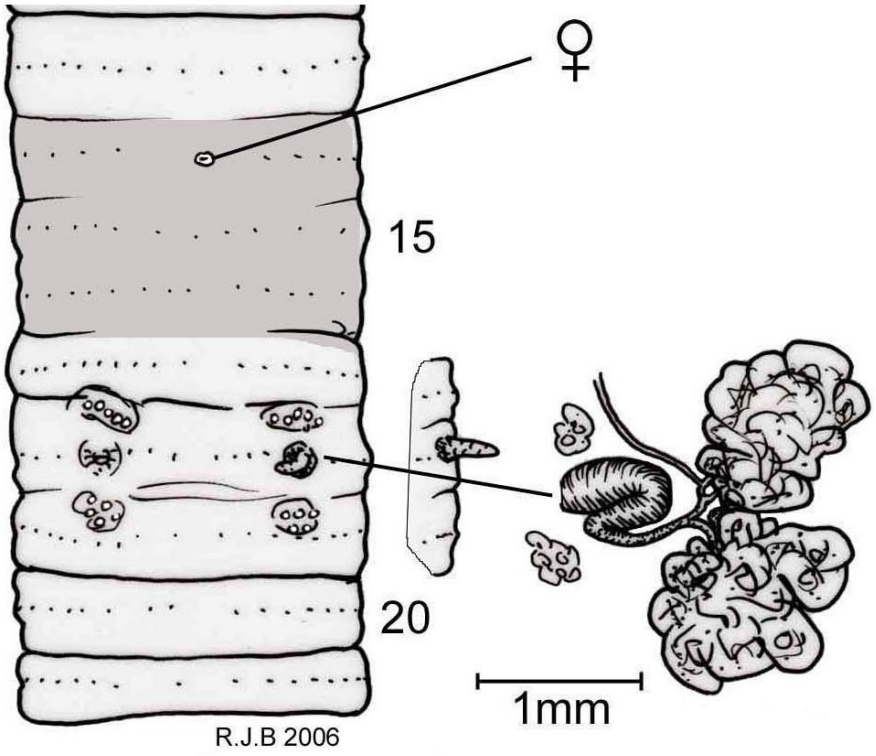

Fig. 5. Details of marginal non-superficial male pores of *Metaphire paka* Blakemore, 2007 in Blakemore *et al.*, 2007, Mt Kinabalu specimen showing male field with copulatory pouch (lhs) and everted penis (on rhs plus its lateral view).

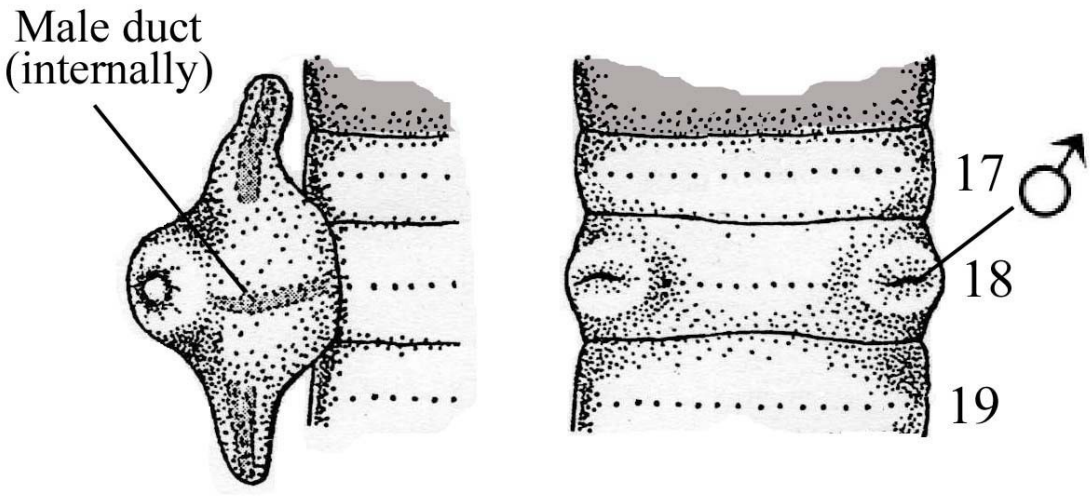

Fig. 6. Detail of everted non-superficial male pores and intromittent organs (lhs) and uneverted pores (rhs) of *Duplodicodrilus schmardae* (Horst, 1883) (after Hatai and Ohfuchi, 1936: figs. 4, and 8 for their *Pheretima kikuchii* synonym).

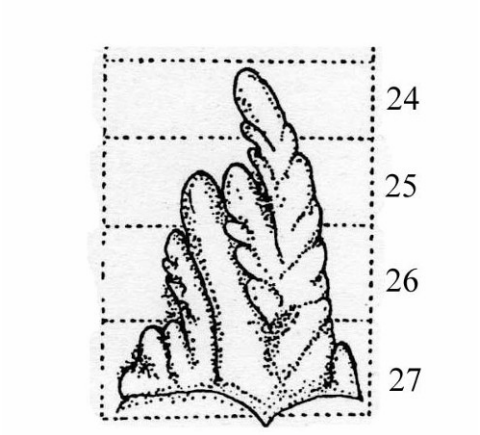

Fig. 7. Detail of manicate (or multiple) intestinal caeca of *D. schmardae* (after Hatai and Ohfuchi, 1936: fig. 9 for their *P. kikuchii*

synonym).